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METHODOLOGY FOR THE SELECTION OF CHEMICAL TEXTILE PRODUCTS

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ABSTRACT

The development of new processes in the textile industry entails designing methodologies to select adequate supplies that fit these new processes requirements. This paper presents a methodology used to select a textile binder that fulfill technical specifications of a new process to produce nonwoven fabrics, highlighting mainly its ability to form a protective film on the textile fibers and cohesion them without staining, weakening or breaking them. The proposed methodology involves three major phases: (1) consulting textile experts, (2) laboratory tests, and (3) factor weighting. The results indicate that there are two products that can be used in this new process: Arkofil and Size plus AC.

KEYWORDS: Binder, Chemical Products, Selection Methodology, Textile Supplies & Textile Fiber

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Original Article

INTRODUCTION

Non-woven textiles are commonly known for being flat oriented veils of fiber which are not woven. They obtain variant forms and are used in the industry for diverse applications like cable isolation and disposable diapers manufacturing. A new process is being technified in order to elaborate non-woven textiles with animal, vegetable and synthetic fibers. This process requires, among other supplies, a textile binder that allows us to form a film that covers the fibers and bonds the fibers for further processing; without damaging the fibers in the process.

There exist a lot of textile binders in the market, from which, it is not known which one meets the requirements needed for new textile processes. The objective of this research was to determine one or more textile binders that will fit to the requirements needed for a new textile process.

THEORETICAL FRAMEWORK

Textile Fiber

A fiber is a solid with a small cross section and an elevated relation between longitude-section. A fiber is composed by millions of long molecular individual chains, with a discrete chemical structure. The molecular structure (disposition and orientation of this molecules), as well as the morphology of the fiber (form and thickness of the cross-section) affect its properties; but the first will determine its basic physic and chemical nature (Lockuán, 2013).

According to Lockuán (2013), for a fiber to be considered as textile, it must fulfill 03 requisites:

- **Flexibility:** A textile fiber must put up with repeated push-ups without diminishing its resistance to breakage, that is that makes it possible to transform the fibers into yarns and weaves; moreover, the flexibility degree determines the ease with which the weaves can be folded, and this will influence in the durability of the garment.

- **Elasticity:** It is important because it facilitates weaving, increases the life of the material and it is important in the textile finishing processes.
- **Tenacity:** This property considerably varies among the different fibers. To be worked and processed by the weaving and spinning machines, the fibers must be tenacious (Resistant to traction), in order to obtain a product of adequate durability for the final use.

Every fiber without this three conditions, will not be useful to manufacture yarns with the technical features that a good quality weave requires. The fiber is the fundamental unit of the textile, from which the yarns are manufactured, the weaves are elaborated, and finally the garments are done.

Classification of Textile Fibers

A first great division of textiles fibers is the one that classifies them in natural and manufactured fibers.

- **Natural Fibers:** They are found in nature and are extracted through physical or mechanical processes. According to their origin they can be: vegetable (seed fibers, stem fibers or leaf fibers), animal (Wool, cashmere, silk, animal hair), and mineral.
- **Manufactured Fibers:** These fibers are man-made and can be obtained from natural polymers or from synthetic polymers; the first group are known as artificial regenerated fibers and the second one are denominated synthetic fibers.

For the purpose of the present investigation we should highlight the classification of the textile products: filiform textiles (Threads), sheetform textiles (sheets and stripes). This last group can be divided in non-woven (conglomerated layered fibers), plain weaving, know weaving, and weavings which have structures that differ with the ones mentioned above (crochet, laces, among others), also with hand-made carpet fabrics and others. (Baltanás, Cougniet & Fourcade, s.f.).

Nonwoven Textiles

Nonwoven fabrics are broadly defined as sheet or web structures bonded together by entangling fiber or filaments (and by perforating films) mechanically, thermally, or chemically. They are flat, porous sheets that are made directly from separate fibers or from molten plastic or plastic film. They are not made by weaving or knitting and do not require converting the fibers to yarn (INDA, 2014).

Applications

According to INDA (2014); non-woven fabrics open up a world of innovative possibilities for all types of industries. Nonwovens may be a limited-life, single-use fabric or a very durable fabric. Nonwoven fabrics provide specific functions such as absorbency, liquid repellency, resilience, stretch, softness, strength, flame retardancy, washability, cushioning, filtering, bacterial barriers and sterility. These properties are often combined to create fabrics suited for specific jobs while achieving a good balance between product use-life and cost. They can mimic the appearance, texture and strength of a woven fabric, and can be as bulky as the thickest paddings (p.1). Following are just a few of the properties that can be attained using nonwoven fabrics: absorbency, bacterial barrier, cushioning, filtering, flame retardancy, liquid repellency, resilience, softness, sterility, strength, stretch and washability (INDA, 2014, p.1).

Today, innovations in nonwoven fabrics are growing as fast as the demand for them, with almost unlimited possibilities for a wide variety of industries, including: agricultural coverings, agricultural seed strips, apparel linings,

automotive headliners, automotive, upholstery, carpeting, civil engineering fabrics, civil engineering geotextiles, disposable diapers, envelopes, filters, house wraps, household & personal wipes, hygiene products, insulation, labels, laundry aids, roofing, sterile medical-use products, tags, upholstery and wall coverings (INDA, 2014).

Textile Binders

We can define a textile binder product as a substance that is capable of adhering to textile fibers and forming a film (Lockuán, 2012). The application of the binder above the textiles fibers forms a film that must present the following characteristics:

- **Resistance to Traction:** It must be able to hold the effort of traction before breaking (RAE, 2001).
- **Flexible:** It has the disposition to easily bend. (RAE, 2001).
- **Elastic:** It can recover more or less completely its form and extension as soon as the action that was deforming it ceases. (RAE, 2001).
- **Abrasion Resistant:** It must not tear or wear due to friction (RAE, 2001).
- **Resistance to Storage:** That it does not harm of lose its properties while being stored. This characteristic also refers to the moment when the binder is applied in the fibers, it remains there until a washing process occurs.
- **Soluble:** The binder can be easily eliminate from the fibers by a simple washing process.
- **Adherent:** It must stick to the fibers and link them together.
- **Antistatic Effect:** It must eliminate the accumulation of static electricity in the fiber.
- **Resistant to Oxidation for the Exposure to Light and/or Air:** That the fiber do not oxide nor generate fungus or bacteria once the binder has been applied and the film has been formed.
- **It Must Not Die the Fibers:** Once the fibers are washed, they must maintain its natural color.

Kinds of Textile Binders

Generally, textile binders present the same behavior once they are applied in the fibers, mostly differencing because of their origin. This way we can find natural and synthetic binders:

- **Natural Binders:** Within the natural binders we can highlight: Starch or starches, modified starches, and albumin glues. (Lockuán, 2012).
- **Synthetic Binders:** Within the binders of synthetic origin we can highlight: Polyvinyl alcohol, polyacrylic acid glues, acrylic polymer adhesives and polyester resins. (Lockuán, 2012).

METHODOLOGY

The procedures for the selection of a textile binder that complies with the technical specifications of a new manufacturing process of non-woven textiles is constituted by 3 phases: Experts consulting, laboratory tests and factor weight.

Expert Consulting

The first stage was carried out with the purpose of determining the most common types of textile binders used in similar applications; and the technical and operative characteristics the binders must fulfill. The textile experts consulted were a chemical engineer with more than 30 year of experience in the textile industry and a textile technician expert in non-woven textile processes. The main factors that must be assessed for the textile binder selection are:

- **Excluding Factors**

Film Formation and Fiber Cohesion: The textile binder must form a film above the textile to link them together. This film must be consistent enough to allow the manipulation of the textile fibers. It must also possess a high degree of cohesion.

Behavior with Textile Fibers: There are three main aspects: (1) the selected textile binder must not change the natural color of the fibers both during the first contact and the washing process, (2) the product must not damage the fibers during its removal process and, (3) y must not generate any kind of reaction that can damage the fibers of affect its quality.

- **Non-Excluding Factors**

Ease of Preparation: The preparation methodology and the time invested will be directly related to its physical conditions (state of matter and concentration) in which the binder is found when acquired. It was taken into account that the binder must be liquid with an average concentration of 6%[1].

Ease of Application: The binder must be practical when applied to the textile fibers; taking into account the application method and the instrument used in order to allow the aspersion of the binder in the full area of the fibers.

Ease of Storage: Certain products present specific conditions that must be taken into account for their storage.

Ease of Washing: The binder will allows us to link the fiber for a subsequent process. Once the binder is used, it must be easily removed in normal conditions without need of chemical or biological agents. Thus, this factor will allow us to obtain a minor washing time and less operational costs.

Price: The price of the binder directly influences the final cost products.

The textile binders recommended by the textile experts to develop the laboratory essay were:

Size Plus A, B, AC (Polyvinyl Alcohol): It is a biodegradable and hydrophilic polymer, with multiple uses in plastic manufacture, in the textile industry and in the pharmaceutical industry. It is mainly used as an adhesive and as a film formation agent (Cabrera, Paredes, Urday& Santiago, 2007). This product is a mix of polyvinyl alcohol, anti-static lubricants, cohesives, moisturizers and antibacterial agents. Its presentation varies regarding its viscosity levels, having the following appearances:

- **Size Plus A:** Medium level of viscosity.
- **Size Plus B:** Low level of viscosity.
- **Size Plus AC:** Medium level of viscosity.

[1]% is based on weight/volume.

Synthetic Cola: Made from vinyl polyacetate, it allows the formation of a film that is water soluble and biodegradable; nevertheless, the melting of this product is laborious.

Starch: This product is used on a wide set of applications, from giving texture and consistency to food, to paper manufacturing (Zhao, Whistler, 1994). It is used as a thickener, stabilizer and gelling agent. This product is formed by glucose polymers, and it is a natural binder. Its presentation is in grains.

Arkofil: Binding agent used in cotton yarns, wool, linen and discontinuous synthetic fibers. It possesses polyvinyl alcohol of medium viscosity and its molecular form is totally saponified, which gives flexibility and softness to the formed film. (Achroma Management LLC, 2014).

Elvanol 51 -01: Polyvinyl alcohol solid binder that represents a low viscosity. It does not reacts with the fiber when it comes into contact, and is cold water soluble. The preparing process is through hydrolysis (Dupont, s.f.).

Elvanol 52-02: Polyvinyl alcohol solid binder partially hydrolyzed of a medium viscosity. It has the capacity to form a film above the fibers and it is soluble in water at normal conditions. (Dupont, s.f.).

Laboratory Tests

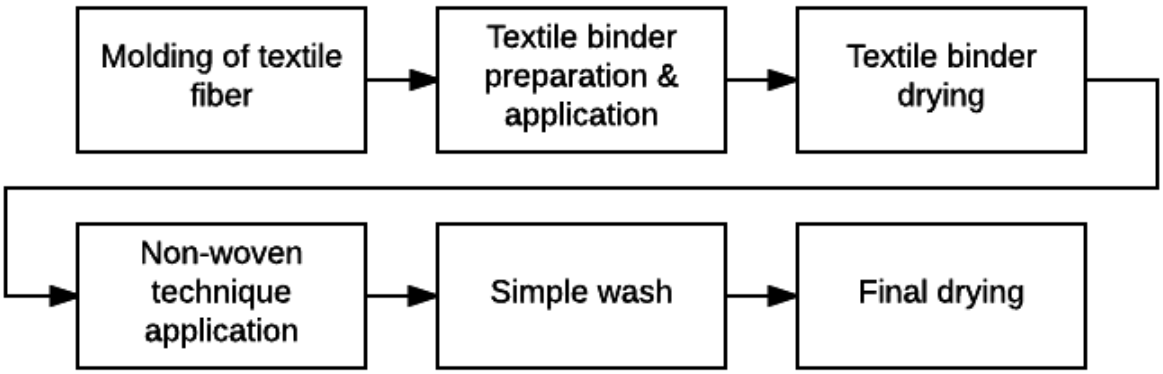

Figure 1: Proposed Experimental Procedure to Test the Textile Binders

The *figure 1* shows the experimental procedures: The first stage was the molding of the textiles fibers for the experimentation, where a diverse set of textile fibers were selected. This fibers were stretched to obtain an approximate panel size of 13 x 13 centimeters, conditioning two layers; one placed horizontally and the other one vertically forming a single panel. The selected fibers were:

Combed alpaca (Natural fiber, animal origin).

Raw alpaca (Natural fiber, animal origin).

Raw llama (Natural fiber, animal origin).

Combed wool (Natural fiber, animal origin).

Raw wool (Natural fiber, animal origin).

Reprocessed Nylon (Synthetic fiber).

Combed Acrylic (Synthetic fiber)

Reprocessed Agave (Natural fiber, vegetal origin).

Reprocessed Jute (Natural fiber, vegetal origin).

The second stage consists in the preparation and application of the textile binder. The preparation was made in consideration of the manufacturer indications. The application was performed twice over the surface of the panels using a dismantling gun to give uniform layers. Afterwards, it was checked through touch that the whole surface was covered without blank spaces.

In the third stage, the drying of the textile binder was performed by exposing the panel for 3 hours in environmental conditions. The panel did not had to present any sign of humidity; and this was reviewed by viewing and touching the panel; also, the formation of the film was corroborated and the behavior of the binder with the fibers was analyzed.

In the fourth stage, a non-woven technique was applied over the panel; in order to keep the fibers together for the subsequent washing process.

In the fifth stage, a simple washing procedure was performed by submerging the fiber in cold water for 10 minutes, draining them manually for 1 minute and submerging them again for an additional 10 minutes.

In the sixth stage, the last drying was performed by extending the panels and exposing them to environmental conditions until they completely dried up. After this, the final properties of the product were immediately revised using: (1) Touch analysis to look for binder remains and (2) Visual analysis and touch analysis to determine if there were any damage, breakage or discolor of the fibers.

During the laboratory tests, the following products presented problems with the excluding factors for which they were discarded before undertaking future analysis:

- Size plus B &Elvanol 52-02: The film was too thin and it did not allow the cohesion between textile fibers.
- Synthetic Cola: The fibers broke during the washing process, due to the film from this product were too thick.

Factor Weighting

Table 1 shows the relation of importance between the factors evaluated, where the importance of each factor was determined.

Table 1: Comparison between Factors to Determine their Relative Weight

Factors	Ease of Application	Ease of Preparation	Price	Ease of Storage	Ease of Washing	Total	Weight
Ease of application	3	4	2	3	1	13	0.17
Ease of preparation	2	3	3	4	1	13	0.17
Price	4	3	3	5	2	17	0.23
Ease of storage	3	2	1	3	1	10	0.13
Ease of washing	5	5	4	3	3	22	0.29
Total						**75**	**1.00**
Note: The grading was made using the following values: 1-Much less important, 2-Less important, 3-As important as, 4-More important, 5-Much more important							

RESULTS

Table 2 shows the results of the textile binders versus the non-excluding factors. Later, a value between 1 and 5 was assigned to each product according to its behavior regarding the factors to obtain the punctuation presented in table 3.

Table 2: Factor Analysis of Textile Binders

Product	Ease of Preparation	Ease of Storage	Ease of Application	Ease of Washing	Cost (USD + 18% TAX)
Size Plus A	No preparation is required. The formula comes in a liquid state.	No problems with storage presented.	No problems with application presented.	No problems with washing presented.	1.86 USD per liter.
Size Plus AC	No preparation is required. The formula comes in a liquid state.	No problems with storage presented.	No problems with application presented.	No problems with washing presented.	1.5 USD per liter.
Starch	Relatively simple preparation. The starch is combined with hot water, and is constantly move until it is completely dissolved.	Solid starch is easily stored. Liquid starch must be kept in low temperatures to avoid decomposition.	No problems with application presented.	Hot water and an enzyme must be used to completely remove the starch.	0.06 USD per liter. (With a 10% w/v concentration)
Arkofil	Relatively laborious preparation. A hydrolyzed solution must be first prepared and then it must be diluted to the preferred concentration.	No problems with storage presented.	No problems with application presented.	No problems with washing presented.	0.06 USD per liter. (With a 10% w/v concentration)
Elvanol	Relatively laborious preparation. A hydrolyzed solution must be first prepared and then it must be diluted to the preferred concentration.	Solid elvanol is easily stored. Liquid Elvanol must be kept in low temperatures for it will react and emit ammonia.	No problems with application presented.	No problems with washing presented.	0.05 USD per liter. (With a 10% w/v concentration)

Table 3: Comparison of Textile Binders by Weighted Factors

Factor	Punctuation	Arkofil	Elvanol	Size Plus A	Size Plus AC	Starch
Ease of application	0.17	5	5	5	5	5
Ease of preparation	0.17	1	1	5	5	2
Price	0.23	5	5	1	2	5
Ease of storage	0.13	5	2	5	5	1
Ease of washing	0.09	5	5	5	5	1
Total	1.00	4.27	3.88	4.03	4.26	2.76
Note: The grading was made in function to the following values: 1-Deficient, 2-Bad, 3-Standard, 4-Good and 5-Excelent.						

CONCLUSIONS

To determine one or more binders that fit new textile process requirements for the production of nonwoven fabrics, it is fundamental the design and application of an adequate methodology that allows obtaining good results.

It was determined that the technical and operational characteristics must fit the textile binder to ensure adequate fiber compaction and to maintain the quality of the end product.

According to the results obtained, two textile binders were selected: Arkofil and Size Plus AC. Both fit the excluding factors (film formation and fiber cohesion, behavior with textile fibers) and the non-excluding factors (Ease of preparation, ease of application, ease of storage, ease of washing, price) initially determined.

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